MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 2, 2018/2019

PGC0225 – GENERAL CHEMISTRY

(Foundation in Life Sciences students only)

9 March 2019
2.30 p.m – 4.30 p.m

(2 Hours)

INSTRUCTIONS TO STUDENTS

1. This question paper consists of **6** pages with **5** questions only.
2. Answer **ALL** questions.
3. Please write all your answers in the answer booklet provided.
4. Distribution of marks for each question is given.
5. Calculator is permitted.

Instructions: Answer **ALL** questions.

Question 1 [10 marks]

a. The balanced equation for the reaction between magnesium nitride (Mg_3N_2) and sulfuric acid (H_2SO_4) is given as

$$Mg_3N_2\,(s) + 4\,H_2SO_4\,(aq) \rightarrow 3\,MgSO_4\,(aq) + (NH_4)_2SO_4\,(aq)$$

It is known that the limiting reagent is Mg_3N_2 and the amount of it that is available for the reaction above is 3.5 moles. Based on this, answer the following:
[Atomic mass: Mg = 24.31; N = 14.01; H = 1.00; S = 32.07; O = 16.00]

(i) Determine the amount (in grams) of H_2SO_4 (as the excess reactant) that is consumed in the reaction with Mg_3N_2. [½ mark]

(ii) Determine the amounts (in grams) of $MgSO_4$ and $(NH_4)_2SO_4$ that are expected to be produced in this reaction if the 3.5 moles of Mg_3N_2 is completely used up. [1 mark]

(iii) If the percent yield of $(NH_4)_2SO_4$ is discovered to be only 54%, calculate the actual yield (in grams) of $(NH_4)_2SO_4$. [½ mark]

(iv) Suppose in another example not related to part (i), (ii) or (iii), in which you have only 1 gram of Mg_3N_2 and 1 gram of H_2SO_4, how many grams of $MgSO_4$ can you produce in theory? [2 marks]

b. Solve the following which involves the concept of solution stoichiometry by providing the final concentration: A mixture made up of 500 mL of 0.30 M HNO_3 and 250 mL of 0.20 M HNO_3 that have been evenly mixed together. [2 marks]

c. Use Hess's Law to calculate the heat of reaction ($\Delta H°_{rxn}$) for reaction (1) and determine the amount of heat that will be evolved if 14.02 g of calcium oxide (CaO) reacts with sulfuric acid (H_2SO_4) as shown in reaction (1):
[Atomic mass: Ca = 40.08; O = 16.00]

$$CaO\,(s) + H_2SO_4\,(g) \rightarrow CaSO_4\,(s) + H_2O\,(l) \quad \ldots\text{reaction (1)}$$

You are given the following balanced thermochemical equations:

$Ca\,(s) + \frac{1}{2}O_2\,(g) \rightarrow CaO\,(s)$	$\Delta H° = -152$ kJ/mol
$Ca\,(s) + S\,(s) + 2\,O_2\,(g) \rightarrow CaSO_4\,(s)$	$\Delta H° = -1434$ kJ/mol
$H_2\,(g) + \frac{1}{2}O_2\,(g) \rightarrow H_2O\,(l)$	$\Delta H° = -286$ kJ/mol
$H_2\,(g) + S\,(s) + 2\,O_2\,(g) \rightarrow H_2SO_4\,(g)$	$\Delta H° = -814$ kJ/mol

[4 marks]

Continued.....

Question 2 [10 marks]

a. Figure 1 below indicates the position of 6 unnamed elements in the periodic table. These 6 elements have been labeled '**O**', '**P**', '**Q**', '**R**', '**S**' and '**T**'.

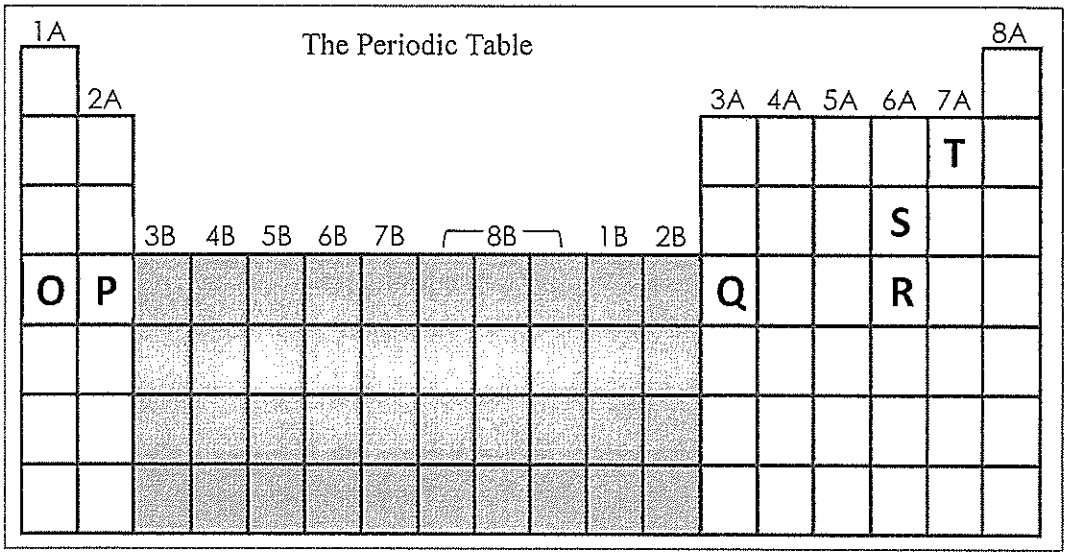


Figure 1

Based on the information given in Figure 1, answer the following:

(i) Arrange the 6 elements in terms of their atomic radii in an increasing order. Begin with the element which has the smallest atomic radius. [2 marks]

(ii) Which element is likely to have the largest ionic radius when all the 6 labeled elements above form their respective ions? [1 mark]

(iii) Predict the molecular formula of the compound made up of '**P**' and '**S**'. [½ mark]

(iv) Predict the molecular formula of the compound made up of '**Q**' and '**T**'. [½ mark]

b. Provide the *electron configurations* for the following examples:

(i) Copper (symbol = Cu; atomic number of Cu = 29) [1 mark]
(ii) Germanium (symbol = Ge; atomic number of Ge = 32) [1 mark]
(iii) Bromine ion (symbol = Br^-; atomic number of Br = 35) [1 mark]

c. What is the maximum number of electrons that can occupy each of the following?

(i) $4f$ [½ mark]
(ii) $3d_{xz}$ [½ mark]
(iii) $n = 4$ [1 mark]
(iv) $n = 6$ [1 mark]

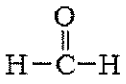
Continued.....

Question 3 [10 marks]

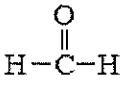
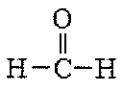
a. Draw the Lewis structure and determine the molecular geometry using the VSEPR model for:

(i) CBr_4 [1½ marks]
(ii) PH_3 [1½ marks]

b. List all types of intermolecular forces that exist between each of the following molecules.

(i)  and Na^+

[1 mark]

(ii)  and 

[1 mark]

c. Figure 2 shows the phase diagram for water, H_2O.

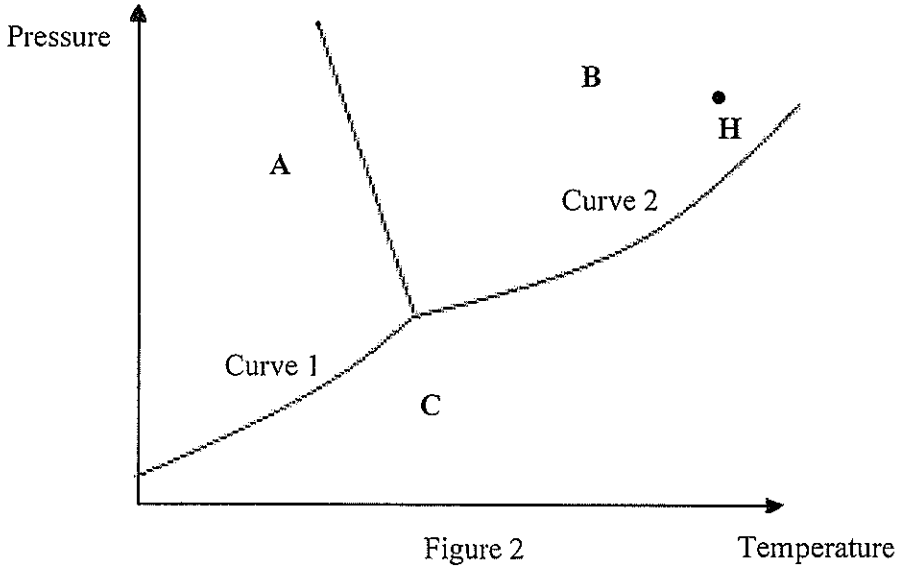


Figure 2

(i) Label the regions A, B and C. [1½ marks]
(ii) What curve corresponds to conditions at which the solid and gas are in equilibrium? [½ mark]
(iii) What happens when you start at point H and decrease the pressure at constant temperature? [½ mark]

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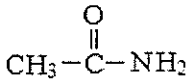
d. Show the hydrogen bonding of each of the following molecules by drawing two molecules of the substances below with the hydrogen bonds between them.

(i) CH_3OH [½ mark]

(ii)  [½ mark]

e. Figure 3 shows the molecule of riboflavin (vitamin B2).

(i) How many carbons are sp^3 hybridized? [½ mark]
(ii) How many carbons are *sp* hybridized? [½ mark]
(iii) Determine the number of pi (π) bonds in this molecule. [½ mark]

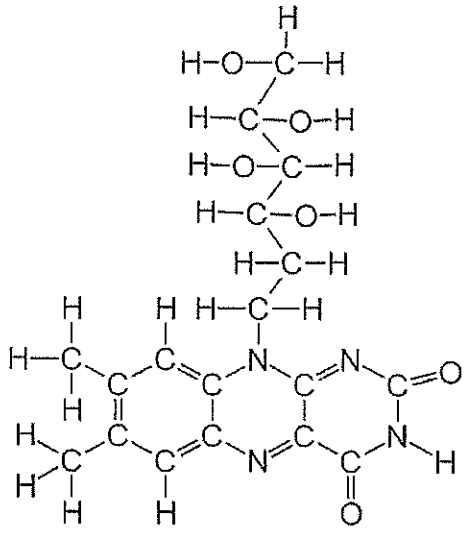


Figure 3

Continued.....

Question 4 [10 marks]

a. The following data were measured for the reaction of nitric oxide with hydrogen:

$$2\,NO(g) + 2\,H_2(g) \longrightarrow N_2(g) + 2\,H_2O(g)$$

Experiment	[NO] (M)	[H_2] (M)	Initial Rate (M/s)
1	0.10	0.10	1.23×10^{-3}
2	0.10	0.20	2.46×10^{-3}
3	0.20	0.10	4.92×10^{-3}

(i) Determine the rate law for this reaction. [3 marks]
(ii) Calculate the rate constant. [1 mark]
(iii) Calculate the rate when [NO] = 0.050 M and [H_2] = 0.150 M. [1 mark]

b. The decomposition of an insecticide (A) in water follows first-order kinetics with a rate constant of 1.45 yr^{-1}. A quantity of this insecticide is washed into a lake on June 1, leading to a concentration of 5.0×10^{-7} M.

(i) What is the concentration of the insecticide (A) on June 1 of the following year? [1½ marks]
(ii) How long will it take for the insecticide concentration to decrease to 3.0×10^{-7} M? [1 mark]

c. Consider the following equilibrium process at 686°C :

$$CO_2(g) + H_2 \rightleftharpoons CO(g) + H_2O(g)$$

The equilibrium concentrations of the reacting species are:
[CO] = 0.050 M, [H_2] = 0.045 M, [CO_2] = 0.086 M, and [H_2O] = 0.040 M.

(i) Calculate Kc for the reaction at 686°C. [1 mark]
(ii) If some of the CO_2 were removed from the system, which direction will the reaction shift? [½ mark]
(iii) If water is added to the system at equilibrium, what will happen to the hydrogen concentration? [½ mark]
(iv) If we use a catalyst, which way will the reaction shift? [½ mark]

Continued.....

Question 5 [10 marks]

a. The following questions refer to the classical definition and understanding of acid-base reactions

(i) According to Arrhenius, what is the definition of neutralization? [1 mark]
(ii) Provide a clear example of a neutralization reaction. Write the balanced chemical equation for this example. [1 mark]
(iii) State two limitations of Arrhenius' theory in explaining the properties of common acids and bases. [1 mark]

b. (i) Arrange the following molecules in order of *increasing* acid strength: HClO, $HClO_2$, $HClO_3$, $HClO_4$. Explain briefly. [2 marks]
(ii) In comparing three solutions with pHs of 2.0, 4.8, and 5.2, which has the highest H^+ concentration? Which is most acidic? [1 mark]

c. A wildlife biologist is interested in testing the pH of the water in a lake. He obtains a 200 mL sample of the water and titrates this sample with a 0.050 M NaOH solution. Neutralization of the lake water requires 40 mL of the NaOH solution.

(i) Is the lake acidic, basic, or neutral? [½ mark]
(ii) If the size of the lake can be described as 1.1 km long by 2.3 km wide, and has a depth of 10 m, estimate how many moles of monoprotic acid are present in the lake water.

[1½ marks]

d. The pH of a sample of river water is 6.0. A sample of effluent from a food processing plant has a pH of 4.0. What is the ratio of hydronium ion concentration in the effluent to the ion concentration in the river? [2 marks]

End of Paper